Instruction Manual

REGULATED HIGH VOLTAGE SUPPLY

Model RQE-1601-5121

Ser. No. 190

Northeast Scientific Corporation

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DANGER

WARNING

The output power and voltage level from this equipment can be high enough to kill or at least to cause serious injury. For this reason, the supply should always be operated completely enclosed, i.e., with the case on, and every care should be taken to avoid personal contact with the output leads or with the load being fed by the supply during the time that it is operating.

Although the equipment should be perfectly safe when the filaments only are energized (power switch in ST'D BY position), a good rule to follow is to turn it off completely when it is necessary to make adjustments that require personal contact with leads and components at a high potential with their surroundings.

REMEMBER

NO LIGHTS:	Completely off.
Amber or ONE LIGHT:	Stand-by position, filaments only applied.
Red and amber or TWO LIGHTS	HIGH VOLTAGE ON. BE CAREFUL.

SPECIFICATIONS

Model RQE-1601-5121

Output Voltage: 0 to 1.6 KV DC, continuously variable in steps of 100 and 10 Volts in conjunction with a 0 to 12 Volt Vernier. Output Voltage is within 0.5% of Calibration.

Output Current: 0 to 10 Milliamperes, Full-load.

Polarity: Either side of the Output may be grounded.

Insulation: Output can be floated to plus or minus 8 KV DC.

Overshoot: None under any condition of turn-on. The Output Voltage will not exceed the programmed Voltage determined by the Output Voltage control settings.

Short-circuit Current: Fixed at approximately 14 Ma.

Ripple: Approximately 1 Millivolt maximum, peak to peak.

Regulation: Better than .0005%, No-load to Full-load.

Stability: Better than .0005% for an Input Line Voltage shift from 105 to 125 V AC.

Long-term Stability: .005% per Hour and .05% per Day after warm-up in a normal ambient without sudden and/or wide temperature changes.

Input: 105 to 125 V AC, 50 to 500 HZ., 0.42 Amperes Max., 40 Watts maximum.

Dimensions: Panel is 19" wide by 3-1/2" high with Cabinet 10" deep. Overall depth from front to back is 12-3/4".

Net Weight: 12 Pounds.

I

GENERAL DESCRIPTION

This instrument consists of a high-voltage rectifier followed by a degenerative regulator arranged to supply a very closely regulated DC high-voltage to a load. Either side of the output may be grounded.

The supply is completely AC operated and self-contained. It is compactly housed in a portable case for bench and field use. All operating controls and the output terminals are located on the front panel. The power cord mates with a connector at the back.

The power switch is arranged so that the reference supply and the control tube heater are turned on first. After the tube warms up, high-voltage can be turned on and off at will.

The high-voltage rectifier is a full-wave doubler. A minimum of filtering is used to keep the energy storage low. As the output voltage is decreased, the rectified voltage is also decreased in order to keep the dissipation in the regulator down.

The regulator is a degenerative series type. The control stage is a tetrode, permitting large plate voltage excursions to be applied by the rectifier. A two-stage high-gain balanced differential semiconductor feedback amplifier compares a portion of the output voltage with a stable reference and applies the amplified difference to the control stage so that the output voltage is held within very narrow limits, almost independent of output load current or input line voltage effects.

The reference and the feedback amplifier are powered by a separate auxiliary semiconductor regulated supply. Its output is also controlled by the same reference. Since it operates the feedback amplifier almost immediately after turn-on, and the control tube takes some time to warm up, overshoot of the output voltage is prevented and no time-delay relays are required for protection.

The output voltage is continuously variable over the entire range from zero to 1.6 KV. It is changed by varying the feedback ratio in the regulator by means of switched precision resistors. Once the instrument has been standardized, the output settings are as accurate as the resistors used, and as stable as the resistors and reference element. Factory adjustment is to 0.1% so that allowing for resistance and reference changes with time and temperature, the output is within 0.5% of calibration.

Current feedback is provided to limit the output in the event of overload or short-circuit. The regulator will return to normal with the removal of the fault.

II

OPERATING INSTRUCTIONS

This unit may be operated in any normal location, if it is adequately protected from moisture and excessive dirt. If it has been exposed to dampness, it should be opened and left in a warm dry place until it is thoroughly dry before being operated.

To prevent overheating, it is important that the perforated areas of the top and bottom covers be unobstructed so that there will be adequate ventilation. Otherwise the internal dissipation may raise the internal operating temperature too high. Keeping the temperature down does much to minimize the long term drift of the output voltages with time.

Although the supply has been constructed with care and all components are well supported, excessive vibration and rough handling should be avoided.

The internal voltages developed in this unit are high enough so that it should always be operated with the top and bottom covers in place.

WARNING

The internal and output voltages in this supply are high enough to case permanent or serious injury. For this reason, the supply should always be operated completely enclosed, i.e., with the top and bottom covers in place, and every care taken to avoid personal contact with the output leads and/or the load being fed from it during the time that it is operating.

The supply can also be hazardous even when in the stand-by (ST'D BY) condition, although these internal voltages do not appear at the output terminals. Under these circumstances, it is best to turn the supply off completely when it is necessary to make adjustments that require in some way bodily contact with leads at high potentials.

REMEMBER

NO PILOT LIGHTS: Completely off.

ONE PILOT LIGHT (Yellow): Heater voltages and auxiliary supply voltages on.

TWO PILOT LIGHTS (Yellow and Red): HIGH VOLTAGE ON. BE CAREFUL.

It is suggested that the supply be placed in operation as follows:

1. Check to see that the power switch is in the "OFF" position. This will prevent any harm to the user when making connections.

2. Connect the load to be fed to the output terminals. If one side of the output is to be grounded, connect a jumper between that output terminal and the ground terminal, which is connected to the chassis and case. This can also be connected to a system ground for further protection, if desired.

3. Set the output voltage to what is required or some convenient value by suitable adjustment of the calibrated controls. The operating output voltage will be the sum of the control settings. For instance, if 1245 volts should be required, set the controls to 1.2 KV, 40 V, and 5V on the vernier.

4. Insert the power cord into the AC fitting at the back and plug it into a convenient source of 105 to 125 V AC power. Power line frequency can be from 50 to 500 cps.

5. Turn the power switch to stand-by ("ST'D BY") for warm-up. The left or amber pilot will light indicating stand-by with reference and feedback amplifier active and control tube heater on. The control tube will take about 30 seconds to heat up.

6. After warm-up, advance the power switch to "ON". High voltage output is now on. The right or red pilot will come on to indicate this. Power should now be flowing or available to the load.

7. The high-voltage can be adjusted while the supply is operating, by changing the control settings. The switches give 0.1 KV (100 V) and 10 V steps and the vernier (ΔV) will give a continuous 0 to 12 V variation to interpolate between steps.

The supply will continue to operate properly as long as the maximum output current of 10 milliamperes is not exceeded and the input line voltage does not fall below 105 V AC. Actually, the design permits going down to about 100 V input to allow for design variations and component aging. Should the load be wrong or develop a fault, a simple current feedback stage takes control and limits the maximum output current to about 15 milliamperes. The supply will return to normal operation with removal of the fault.

This unit is designed for portable or field use and can be used in almost any position. It should be remembered, however, that the perforated openings should be unobstructed so that there is sufficient ventilation. Otherwise the regulator will overheat.

III

CALIBRATION/STANDARDIZATION

The calibration accuracy of this unit depends mostly upon the stability of the reference and the accuracy and stability of the feedback resistors. There is one trimming resistor used for a calibration adjustment, which matches the current generated in the feedback resistors to the voltage drop across the reference. During final tests, this adjustment is made so that the output voltage is within 0.1% of true value.

If the reference voltage should change, the reference itself be replaced, or other repairs have been made, it may be desirable to readjust the trimming resistor to bring the calibration back to normal.

For access to these components, remove the top side of the case. Removing the 14 screws holding it will allow it to be taken off. It is not necessary to remove any other side.

The calibration adjustment is the trimming resistor at the upper right hand side of the circuit board. The setting has been locked with some adhesive after being adjusted. It will be necessary to release it. This can be done by appling sparingly some solvent such as acetone of methyl ethyl ketone (MEK) to the adhesive with a small brush until the seal is broken or washed away.

Assuming that the supply is behaving normally in other respects, an accurate voltmeter should be connected to output terminals. The positive side of the output should be grounded for this work.

Initially, set the KV-switch to 1.0 KV and the other controls to zero. Turn on the supply and read the output on the external voltmeter. If the output is 1.0 KV to within 0.5%, no readjustments is necessary. Check again at 1.6 KV and at 0.1 KV. Set the KV-switch to 0 and set the VOLTS-switch to 100. All these should also be in like calibration. All other switch settings should be similar.

If the initial trial at 1.0 KV was not in calibration, adjust the calibration adjustment to bring the output within calibration. If some of the other settings do not give their proper output, then one of the resistors must be at fault, and a step-by-step trial from 0 up will soon locate the bad resistor.

After adjustment, the trimmer should be locked again with some glyptal or other adhesive.

IV

MAINTENANCE

Very little maintenance should be required to keep this supply operating. However, all equipment at one time or other suffer from various failures. In this unit, a serious attempt has been made to have all components accessible for easy test, service, and replacement.

The case can be opened by taking out the screws to remove the top and bottom.

The supply can be turned on and operated with the case off, but one must be very careful because of the exposed high-voltage circuitry.

The control tube and the reference tube can be removed and checked in a tube checker. However, a high impendance voltmeter check across the reference should give something between 83.5 to 85 volts. Erratic operation of the reference can not usually be detected this way, but much more easily by substitution. If another reference tube is used, the calibration may be off, but operation will not be affected otherwise.

When making voltage checks, it is best to ground the positive side of the output. Then the circuit board is essentially at the same potential as the case, and some of the hazards are minimized.

The output of the auxiliary supply measured across the 40K and 200K 1% comparison resistors should be about 100to 103 volts. With the positive output terminal of the main supply grounded, the voltage to the anode of the 5651 reference tube should be about 83.5 to 85 volts. If the input line is varied from 100 to 130 V (rms) by an autotransformer (variac, etc.), these voltages should be very constant. This test can be made with the supply operating at stand-by (ST'D BY) only (i.e., leave the high voltage off.)

Current for the same rectifier and supply is used to establish a +15 volt collector supply and a -15 volt emitter supply for the input differential amplifier. These voltages can be measured across the respective zener diodes. The first one must be measured with the high voltage on. When it is off, enough current is drawn by the amplifier to prevent breakdown across the +15 volt zener.

If this auxiliary supply is delivering the required output and has requisite stability, then any problems remaining will be in the main regulator. Check the components for shorts, etc., and the common emitter junctions in the two balanced amplifier stages for proper voltages. A step-by-step removal and check of individual components may be necessary to find the trouble.

Otherwise, if periodic checking is desired, the supply can be set up with a suitable voltmeter, load and oscilloscope. Input should be fed through an autotransformer (Variac). Input voltage should also be monitored. The input to the scope should

be isolated with a suitable high voltage condenser (0.1 MF 3 KV, etc., high quality) and the scope input put on the DC connection (otherwise the internal condenser in the input might be blown). With the supply delivering 1.6 KV at 10 Ma., it is easy to check regulator operation by observing the ripple trace on the scope (a convenient sensitivity is 1 mv/cm). Ripple should be under 2 millivolts peak-to-peak. Throwing the load on and off (this is best done with a remotely operated vacuum relay in series with the "hot" side of the output) should not make a significant change in this trace. With full-load, reducing the line voltage to 105 or 100 volts should not affect it also. A low line voltage will be found at 100 volts or below where the output ripple will increase a thousand-fold. This means the regulator has stopped working because there is no longer sufficient voltage from the rectifier.

Raising the input voltage to 125 volts should not cause much change to the pattern either. If the input voltage is swung quickly between 105 and 125 volts by manually turning the auto-transformer, the average value of the trace should be quite steady. This indicates that the feedback gain is adequate.

If the output voltage is within calibration at each step, and does not vary with the application of load, at both low and high input line voltage, then the regulator is indeed operating properly. If the scope indicates proper regulator operation, but the output voltage is not correct, even though it does not change with load, then it will be necessary to restandardize the feedback calibration. The procedure is described under IV, Calibration and Standardization.

REGULATED HIGH VOLTAGE SUPPLIES

- High performance supplies for high voltage applications. Specifications given are limits which are usually well exceeded.
- Units are constructed for standard rack mounting, but are suitable for bench use. Some models are available in alternate bench type cases.
- All supplies are insulated for floating operation to 8 Kv DC with respect to chassis and ground.

SEMICONDUCTOR – HYBRID TYPE*

A silicon retifier followed by a transient protected, high performance solid state degenerative feedback regulator having automatic current limiting (variable limiting optional). A high stability gas discharge reference is used (zener diode types are optional). The silicon NPN cascode type control stages make use of vacuum tube upper element to handle high voltage excursions arising from output voltage changing, on-off switching, outside faults, etc., for a very suitable solution for high voltage semiconductor regulator design.

Output voltage will not overshoot the control setting. Voltage calibration is better than 0.5%.

MODEL	Input	Output Voltage	Controls	Full Load Current	Regulation	Stability	Long-Term Stability	Ripple-max. p-p	19 in. Rack Panel height-in.	Front to back overall-in.	Net weight pounds
		Kv		Ma				mv.			
RQE-0503-2XXX	1	0-0.55	u	30	a	f	j	1	3-1/2	12-3/4	12
RQE-1101-2XXX		0-1.1	u	15	a		j		3-1/2	12-3/4	12
RQE-1601-2XXX		0-1.6	u	10	a		j		3-1/2	12-3/4	14
RQE-1603-2XXX			u	30	b		k		5-1/4	12-3/4	20
RQE-1610-2XXX			u	100	c				5-1/4	17	35
RQE-2003-2XXX		0-2	u	30	a				5-1/4	12-3/4	20
RQE-2006-2XXX			u	60	b				5-1/4	14-3/4	27
RQE-3001-2XXX		0-3	v	10	a		j		3-1/2	14-3/4	16
RQE-3002-2XXX			v	20	a				5-1/4	12-3/4	22
RQE-3004-2XXX			v	40	b				5-1/4	14-3/4	31
RQE-3006-2XXX			v	60	b				5-1/4	17	33
RQE-5001-2XXX		0-5	w	10	a				5-1/4	14-3/4	26
RQE-5002-2XXX			w	20	a				5-1/4	17	32
RQE-5003-2XXX			w	30	b	g		2	8-3/4	17	40
RQE-5006-2XXX			w	60	b	g			8-3/4	17	50
RQE-6501-2XXX		0-6.5	w	10	a	f			5-1/4	14-3/4	26
RQE-6202-2XXX			w	20	a	f			5-1/4	17	20
RQE-6503-2XXX			w	30	b	g	k		8-3/4	17	43
RQE-6506-2XXX			w	60	c				8-3/4	17	59
RQE-10010-2XXX		0-10	w	10	b				7	17	40
RQE-10030-2XXX			w	30	c				8-3/4	17	65

VACUUM TUBE SUPPLIES

Units consist of a silicon rectifier followed by a high performance vacuum tube degenerative feedback regulator. A high stability gas discharge reference is used. Output calibration is better than 1%.

Metering, terminal, and switching options available.

Units have had a long history of proven satisfactory performance.

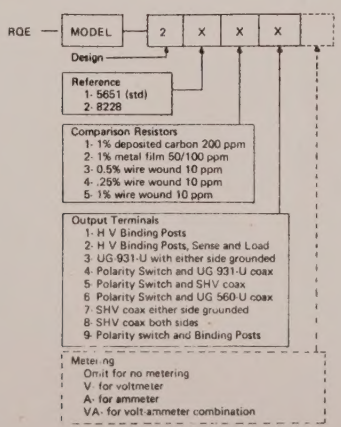
RE-1620	1	0.3-1.6	u	200	d	i	k	2	8-3/4	16-1/2	46
RE-1699	2		u	1000			l	6	22-1/4	16-1/2	157
RE-2015	1	0.5-2	u	150			k	2	8-3/4	16-1/2	51
RE-2060	2		u	600			l	6	22-1/4	16-1/2	140
RE-3006	1	0.5-3	w	60			k	2	8-3/4	16-1/2	35
RE-3010	1			100			k	2	8-3/4	16-1/2	46
RE-3040	2			400			k	6	22-1/4	16-1/2	133
RE-5003	1	0.5-5		30			k	2	8-3/4	16-1/2	37
RE-5006	1			60			k	2	8-3/4	16-1/2	48
RE-5020	2			200			l	10	22-1/4	16-1/2	140
RE-6503	1	0.5-6.5		30			k	2	8-3/4	16-1/2	47
RE-6506	1			60			k	2	8-3/4	16-1/2	57
RE-6520	2			200			l	10	22-1/4	16-1/2	140
RE-10010	1	1-10		10			k	5	8-3/4	16-1/2	38
RE-10030	1			30			k	5	8-3/4	16-1/2	51
RE-10100	2			100			l	10	22-1/4	16-1/2	140
RE-13010	1	1-13		10			k	5	8-3/4	16-1/2	42

INSULATED LOW VOLTAGE SUPPLIES

Compact high performance all solid state regulators with adjustable overload current limiting designed for floating operation to ±8 KV DC. Separate sense and load output terminals are provided.

		Volts		Amps							
RQE-001310-1422V	1	0-13	y	1	e	h		1	3-1/2	12-3/4	9
RQE-001310-2422			z	1				1	3-1/2	12-3/4	9
RQE-001330-1422V		0-13	y	3				1	3-1/2	14-3/4	15
RQE-001330-2422			z	3				1	3-1/2	14-3/4	15

* Options



Input

50/500 Hz { 1- 105/125 V; 2- 200/240 V }

(All units available for 210/250 V operation when required.)

Controls

u- 0-1 Kv and 10 V step switches, 0–12 V vernier
v- 0-2 Kv and 10 V step switches, 0–12 V vernier
w- 0-5 Kv and 50 V step switches, 0–60 V vernier

y- 1 V step switch, 0–1.2 V vernier
z- 0–13 V continuous, voltmeter indication

Regulation

No-load to full-load, better than { a- .0005% or 5 ppm; b- .001% or 10 ppm; c- .002% or 20 ppm; d- .003% or 30 ppm; e- .01% or 100 ppm }

Stability

105 to 125 or 200 to 240 V input change, better than { f- .0005% or 5 ppm; g- .001% or 10 ppm; h- .003% or 30 ppm; i- .01% or 100 ppm }

Long-Term Stability

Constant ambient Temperature, better than { j- .005% /hour, .05%/day; k- .01% /hour, 0.1%/day; l- .02% /hour, 0.2%/day }

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